# Crisis Management Model and Recommended System for Construction and Real Estate

Artūras Kaklauskas[1,*], Edmundas Kazimieras Zavadskas[1], Paulius Kazokaitis[1], Juozas Bivainis[1], Birute Galiniene[2], Maurizio d'Amato[3], Jurga Naimaviciene[1], Vita Urbanaviciene[1], Arturas Vitas[2], Justas Cerkauskas[1]

[1] Vilnius Gediminas Technical University, Sauletekio av. 11, Vilnius, LT-10223, Lithuania
[2] Vilnius University, 3 Universiteto St, LT-01513 Vilnius, Lithuania
[3] Technical University of Bari, via Amendola, 126/B - 70126 Bari, Italy
arturas.kaklauskas@st.vgtu.lt

**Abstract.** Integrated analysis and rational decision-making at the micro-, meso- and macro-levels are needed to mitigate the effects of recession on the construction and real estate sector. Crisis management involves numerous aspects that should be considered in addition to making economic, political and legal/regulatory decisions. These must include social, culture, ethical, psychological, educational, environ- mental, provisional, technological, technical, organizational and managerial aspects. This article presents a model and system for such considerations and discusses certain composite parts of it.

**Keywords:** construction, real estate, crisis management, quantitative and qualitative methods, global development trends, alternatives, Lithuania, Model, System, forecasting.

## 1 Introduction

Various econometrics (e.g., Keynesian models, time-series analysis using multiple regression, Box-Jenkins analysis, Time-varying Parameter Model, duration statistical model, multivariate Logit model, competing-risks hazard models with time-varying covariates, dummy variable approach) and operations research (statistical analysis (discriminant analysis [1], Logit and Probit regression models [2]), artificial neural network models (fuzzy clustering and self-organizing neural networks [3], the back-propagation neural networks model [4]), multiple criteria decision making [5]-[7], artificial intelligence (the support vector machine [8], k-nearest neighbor algorithm [4], and decision tree [9], etc.) methods and models in the construction and real estate sector as well as in separate segments are being applied for crisis management worldwide today. Technical approaches of operations research (decision support systems [5], [10], [11], expert systems [12], mathematical programming [13], multicriteria decision methods [5]) are used for crisis management in different construction and real estate fields.

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* Corresponding author.

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It may be noted that above researchers from various countries engaged in the analysis of crisis in the construction and real estate sectors but they did not consider the research object that is being analyzed by the authors of this present research. The latter may be described as a life cycle of the construction and real estate industry, the stakeholders involved and as the micro, meso and macro environments that have some particular impact on a life cycle in making an integral whole. A complex analysis of the formulated research object was performed with the help of Construction and Real Estate Crisis Management Model and Recommended System which were especially developed for this purpose.

This paper is structured as follows: After this introduction, Section 2 describes Construction and Real Estate Crisis management Model. A sketch of the Recommended Construction and Real Estate Crisis Management System appears in Section 3. Finally Section 4 provides some concluding remarks.

## 2 Construction and Real Estate (CARE) Crisis Management Model

The traditional analysis of a crisis in construction and real estate is based on economic, legal/regulatory, institutional and political aspects. Social, cultural, ethical, psychological and educational aspects of crisis management receive less attention. To perform an integrated analysis of the life cycle of a crisis in the construction and real estate sectors, the cycle must be analyzed in an integrated manner based on a system of criteria (see Figure 1).

The aim of this research was to produce a construction and real estate (hereafter – CARE) crisis management model for Lithuania by undertaking a complex analysis of the micro, meso and macro environmental factors affecting it and to present recommendations on increasing its competitive ability. The research was performed by studying the expertise of advanced industrial economies and by adapting such to Lithuania while taking into consideration its specific history, development level, needs and traditions. A simulation was undertaken to provide insight into the development of an effective environment for the CARE Crisis management Model by choosing rational micro, meso and macro factors.

The word, model, implies “a system of game rules” by which CARE crisis management could be used to its best advantage in Lithuania’s development.

*This research includes the following six stages.*

**Stage I.** A comparative description is written on CARE crisis management in developed countries and in Lithuania which includes: a system of criteria that characterizes crisis management efficiency which is determined by using relevant literature and expert methods; a description based on this system of criteria in conceptual (textual, graphical, numerical, etc.) and quantitative forms on the present state of crisis management in developed countries and in Lithuania.

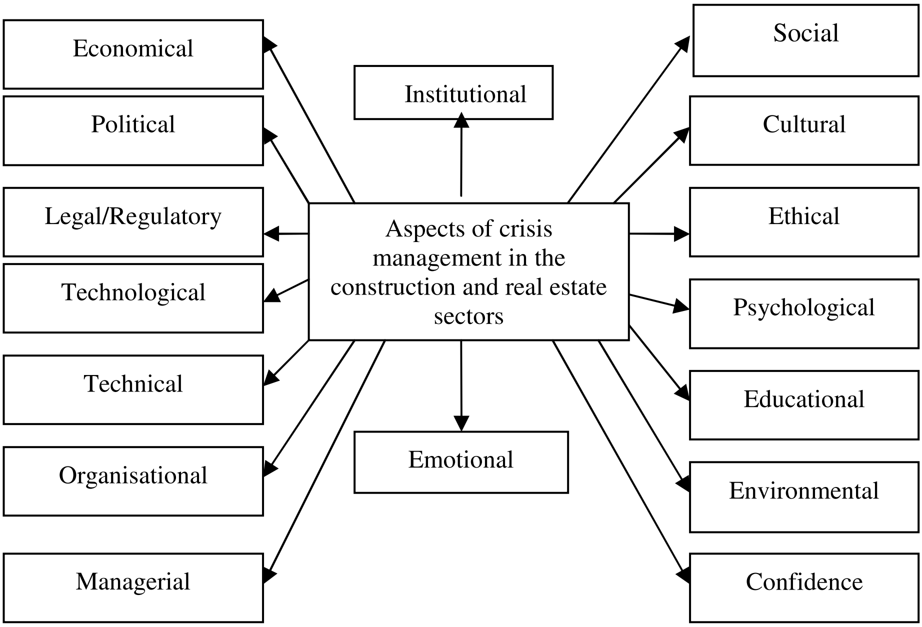


**Fig. 1.** Aspects of crisis management in the construction and real estate sectors

**Stage II.** A comparison and contrast of CARE crisis management in developed countries and in Lithuania are performed which include: an identification of global development trends (general regularities) in crisis management; an identification of crisis management differences between developed countries and Lithuania; a determination of the pluses and minuses of these differences for Lithuania; establishment of the best crisis management practice for Lithuania based on actual conditions; an estimation of the deviation between the knowledge stakeholders have about the best practice worldwide and their practice-in-use.

**Stage III.** Some general recommendations are developed on how to improve efficiency levels for CARE stakeholders and construction (real estate) firms.

**Stage IV.** Certain recommendations for CARE stakeholders and construction (real estate) firms are submitted. Each of the general recommendations proposed in Stage III contain several specific alternatives.

**Stage V.** A multiple criteria analysis is performed on the components of CARE crisis management, and a selection is made of the most efficient version of the life cycle of crisis management. After this, the gained compatible and rational components of one type of crisis management are joined into a full, crisis management process.

**Stage VI.** Transformational learning is performed, and mentality and actual behavior in practice are redesigned.

## 3 Construction and Real Estate Crisis Management Recommended System

Based on the analysis of existing information, expert and decision support systems and in order to determine most efficient versions of Recommended Construction and Real Estate Crisis Management (RCRECM) System consisting of a database, database management system, model-base, model-base management system and user interface was developed (Figure 2).

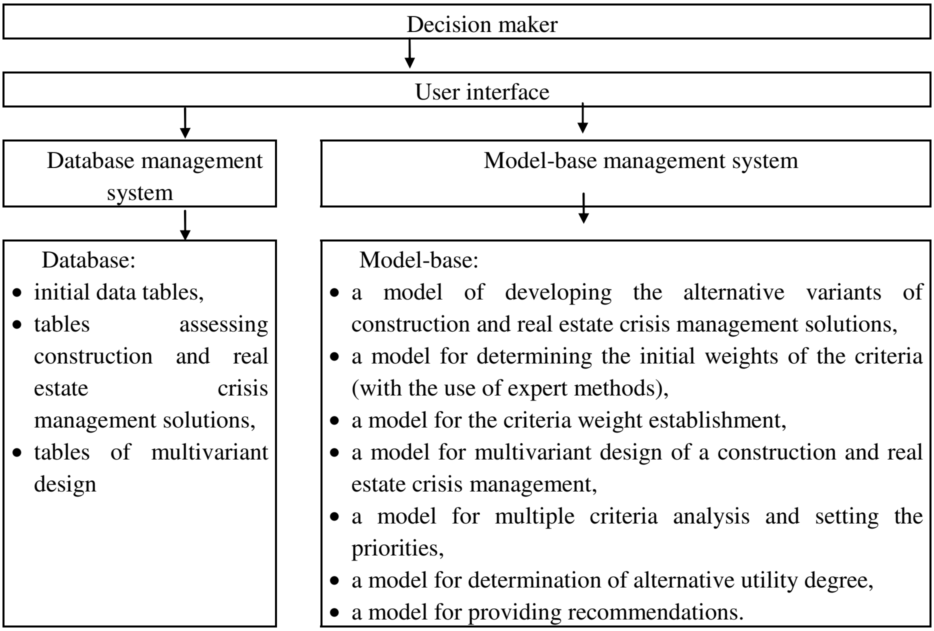


**Fig. 2.** The components of RCRECM system

In order to thoroughly analyze the alternatives available and obtain an efficient compromise solution it is often necessary to define them on the basis of economic, political and legal/regulatory decisions, social, culture, ethical, psychological, educational, environmental, provision, technological, technical, organizational and managerial information (Figure 1). The presentation of information needed for decision making in RCRECM system may be in conceptual (digital (numerical), textual, graphical (diagrams, graphs, drawing, etc), photographical, sound, visual (video)) and quantitative forms.

RCRECM system has a relational database structure when the information is stored in the form of tables. These tables contain quantitative and conceptual information. Logically linked parts of the table make a relational model.

The tables of construction and real estate crisis management variant assessment contain the variants available and their quantitative and conceptual description. Quantitative description of the alternatives deals with the systems and subsystems of criteria fully defining the variants as well as the units of measurement and values and initial weights. Conceptual description defines the alternatives available in a commonly used language giving the reasons and providing grounds for choosing a particular criterion, calculation its value, weight and the like. In this way, RCRECM system enables the decision maker to get various conceptual and quantitative information on construction and real estate crisis management from a database and a model-base allowing him to analyze the above factors and make an efficient solution.

The stakeholders of a construction and real estate sector have their specific needs and financial situation. Therefore, every time when using RCRECM system they may make corrections of the database according to the aims to be achieved and the financial situation available.

The above tables are used as a basis for working out the matrices of decision making. These matrices, along with the use of a model-base and models, make it possible to perform multivariant design and multiple criteria evaluation of construction and real estate crisis management alternatives resulting in the selection of most beneficial variants. In order to design and realise an effective construction and real estate crisis management project the alternatives available should be analysed. Computer-aided multivariant design requires the availability of the tables containing the data on the interconnection of the solutions as well as their compatibility, possible combination and multivariant design.

Based on the above tables of multivariant construction and real estate crisis management design possible variants are being developed. When using a method of multivariant design suggested by the author until 10 000 000 construction and real estate crisis management alternatives may be obtained. These versions are checked for their capacity to meet various requirements. Those which can not satisfy these requirements raised are excluded from further consideration. In designing a number of variants of construction and real estate crisis management the problem of weight compatibility of the criteria arises. In this case, when a complex evaluation of the alternatives is carried out the value of a criterion weight is dependent on the overall criteria being assessed as well as on their values and initial weights.

Since the efficiency of a construction and real estate crisis management variant is often determined taking into account economic, legal/regulatory, institutional, political social, cultural, ethical, psychological and educational and other factors a model-base of a decision support system should include models enabling a decision maker to do a comprehensive analysis of the variants available and make a proper choice. The following models of model-base are aimed to perform this function: a model of developing the alternative variants of construction and real estate crisis management solutions; a model for determining the initial weights of the criteria (with the use of expert methods); a model for the criteria weight establishment; a model for multivariant design of a construction and real estate crisis management; a model for multiple criteria analysis and setting the priorities; a model for determination of alternative utility degree; a model for providing recommendations.

Multiple criteria decision-making methods that the authors herein have developed for the Recommended Construction and Real Estate Crisis Management System are as follows [14]: a method of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics.; a method of multiple criteria complex proportional evaluation of the alternatives; a method of defining the utility and market value of an alternative; a method of multiple criteria multivariant design of a alternative life cycle.

Based on the above models, a RCRECM system can make until 10 000 000 construction and real estate crisis management alternative versions, performing their multiple criteria analysis, determining utility degree and selecting most efficient variant.

To demonstrate the application of the Recommended Construction and Real Estate Crisis Management System a few specific examples from Lithuania have been solved (see Figure 3).

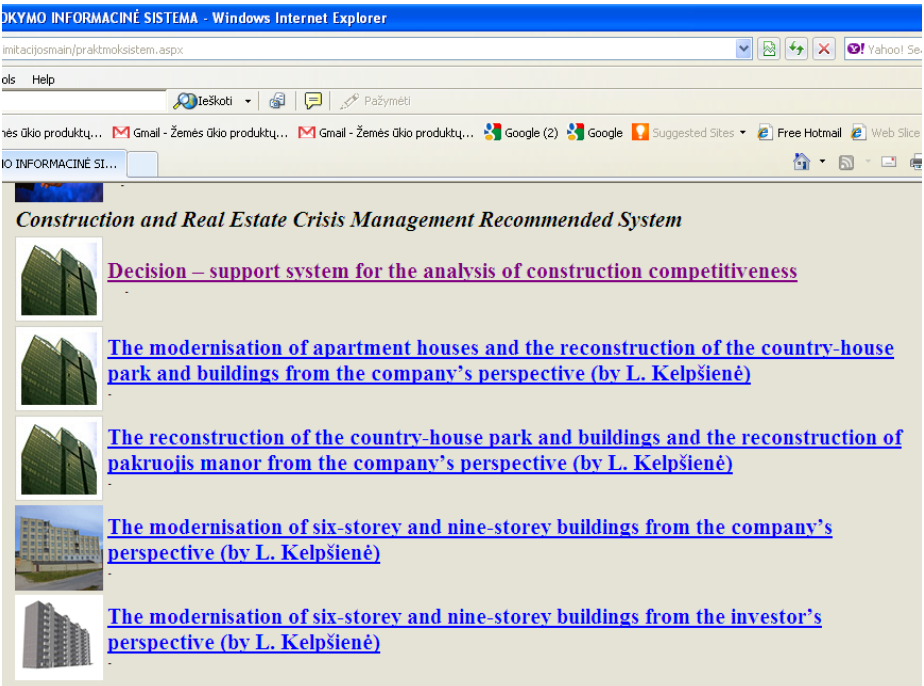


**Fig. 3.** A few specific examples solved by using the Recommended Construction and Real Estate Crisis Management System

The more alternative versions are investigated before making a final decision, the greater is the possibility to achieve a more rational end result. Basing oneself on possessed information and the RCRECM system it is possible to perform multiple criteria analysis of construction and real estate crisis management alternatives components and select the most efficient versions. After this, the received compatible and rational components of a construction and real estate crisis management alternatives are joined up into projects. Having performed multiple criteria analysis of projects made up in such a way, one can select the most efficient ones. Strong and weak sides of investigated projects are also given an analysis. Facts of why and by what degree one version is better than the other are also established. All this is done basing oneself on conceptual and quantitative information.

As example, two models (a model for multiple criteria analysis and setting priorities and a model for determining project utility degree) are described further. A model for multiple criteria analysis and setting priorities performs the multiple criteria analysis of options and sets project priorities based on the weighted criteria and tacit and explicit knowledge. The model for determining the alternative utility degree sets the utility degree for each analysed option. The Complex Proportional Assessment method (COPRAS) [14] is used for these purposes.

The results of the comparative analysis of projects are presented as a grouped decision-making matrix where the columns contain n alternative projects, while all the pertinent quantitative and conceptual information is found in Table 1. Any alternative that has a poorer criterion value than that required is rejected. In order to perform a complete study of a project, a complex evaluation is needed of its aspects (see Figure 1). Quantitative and conceptual descriptions provide this information. The diversity of aspects being assessed should include a variety of data presented as needed for decision-making. Therefore the necessary conceptual information may be presented in numerical, textual, graphical (schemes, graphs, diagrams), virtual and augmented realities or equation formats and as audio or videotapes. An analysis should include all - the criteria used for conceptual descriptions, their definitions and the reasons for the choice of a criteria system and their values and weights. Conceptual information about the possible ways of performing a multivariant design is needed to make a more complete and accurate evaluation. Quantitative information is based on criteria systems and subsystems, units of measure, values and initial weights of the project alternatives. Conceptual information is a more flexible and less accurate means for expressing estimates than numbers are.

**Table 1.** Sorted decision-making matrix for a multiple criteria analysis of alternatives

| Quantitative project information | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Analysed criteria | * | Weight | Units | Analysed projects | | | | | |
| | | | | $a_1$ | $a_2$ | | $a_j$ | | $a_n$ |
| Quantitative criteria | $z_1$ | $q_1$ | $m_1$ | $x_{11}$ | $x_{12}$ | | $x_{1j}$ | | $x_{1n}$ |
| | $z_2$ | $q_2$ | $m_2$ | $x_{21}$ | $x_{22}$ | | $x_{2j}$ | | $x_{2n}$ |
| | ... | ... | ... | ... | ... | | ... | | ... |
| | $z_i$ | $q_i$ | $m_i$ | $x_{i1}$ | $x_{i2}$ | | $x_{ij}$ | | $x_{in}$ |
| | ... | ... | ... | ... | ... | | ... | | ... |
| | $z_t$ | $q_t$ | $m_t$ | $x_{t1}$ | $x_{t2}$ | | $x_{tj}$ | | $x_{tn}$ |
| Qualitative criteria | $z_{t+1}$ | $q_{t+1}$ | $m_{t+1}$ | $x_{t+1\ 1}$ | $x_{t+1\ 2}$ | | $x_{t+1\ j}$ | | $x_{t+1\ n}$ |
| | $z_{t+2}$ | $q_{t+2}$ | $m_{t+2}$ | $x_{t+2\ 1}$ | $x_{t+2\ 2}$ | | $x_{t+2\ j}$ | | $x_{t+2\ n}$ |
| | ... | ... | ... | ... | ... | | ... | | ... |
| | $z_i$ | $q_i$ | $m_i$ | $x_{i1}$ | $x_{i2}$ | | $x_{ij}$ | | $x_{in}$ |
| | ... | ... | ... | ... | ... | | ... | | ... |
| | $z_m$ | $q_m$ | $m_m$ | $x_{m1}$ | $x_{m2}$ | | $x_{mj}$ | | $x_{mn}$ |
| Conceptual information pertinent to projects (i.e. text, graphics, video, virtual and augmented reality) | | | | | | | | | |

Sign $z_i$ (±) shows, respectively, the better/poorer value of the criterion of requirements for better stakeholders satisfaction.

This method assumes direct and proportional dependence of significance and priority by versions investigated on a system of criteria adequately describing the alternatives and on the values and weights of the criteria. A system of criteria is determined, and experts calculate the values and initial weights of criteria. All this information can be adjusted by interested parties considering their goal pursuits and existing capabilities. Hence the results of the assessment of alternatives fully reflect the initial project data that was jointly submitted by experts and interested parties. The determination of the significance and priority of alternatives is carried out in 5 stages.

*Stage* 1: The weighted, normalised decision-making matrix $D$ is formed. The purpose of this stage is to receive dimensionless weighted values from the comparative indexes. When the dimensionless values of the indexes are known, all criteria, originally having different dimensions, can be compared. The following formula is used for this purpose:

$$d_{ij} = \frac{x_{ij} \cdot q_i}{\sum_{j=1}^{n} x_{ij}}, \quad i = \overline{1,m}; \quad j = \overline{1,n}. \tag{1}$$

where $x_{ij}$ - the value of the $i$-th criterion in the $j$-th alternative of a solution; $m$ - the number of criteria; $n$ - the number of the alternatives compared; $q_i$ - significance of i-th criterion.

The sum of dimensionless weighted index values $d_{ij}$ of each criterion $x_i$ is always equal to the significance $q_i$ of this criterion:

$$q_i = \sum_{j=1}^{n} d_{ij}, \quad i = \overline{1,m}; \; j = \overline{1,\, n}. \tag{2}$$

In other words, the value of significance $q_i$ of the investigated criterion is proportionally distributed among all alternative versions $a_j$ according to their values $x_{ij}$.

*Stage 2.* The sums of weighted normalized indexes describing the $j$-th version are calculated. The versions are described by minimizing indexes $S_{-j}$ and maximizing indexes $S_{+j}$. The lower value of minimizing indexes is better (price of the plot and building, etc.). The greater value of maximizing indexes is better (comfortability and aesthetics of the building, etc.). The sums are calculated according to the formula:

$$S_{+j} = \sum_{i=1}^{m} d_{+ij}; \quad S_{-j} = \sum_{i=1}^{m} d_{-ij}, \quad i = \overline{1,m}; \; j = \overline{1,\, n}. \tag{3}$$

In this case, the values $S_{+j}$ (the greater is this value (project 'pluses'), the more satisfied are the interested parties) and $S_{-j}$ (the lower is this value (project 'minuses'), the better is goal attainment by the interested parties) express the degree of goals attained by the interested parties in each alternative project. In any case the sums of 'pluses' $S_{+j}$ and 'minuses' $S_{-j}$ of all alternative projects are always respectively equal to all sums of significances of maximizing and minimizing criteria:

$$S_{+}=\sum_{j=1}^{n} S_{+j} = \sum_{i=1}^{m}\sum_{j=1}^{n} d_{+ij},$$
$$S_{-}=\sum_{j=1}^{n} S_{-j} = \sum_{i=1}^{m}\sum_{j=1}^{n} d_{-ij}, \quad i=\overline{1,m};\ j=\overline{1,n}. \tag{4}$$

*Stage* 3: The significance (efficiency) of the compared versions is determined by describing the characteristics of positive alternatives ("pluses") and negative alternatives ("minuses"). The relative significance $Q_j$ of each alternative $a_j$ is found according to the formula:

$$Q_j=S_{+j}+\frac{S_{-\min}\cdot\sum_{j=1}^{n} S_{-j}}{S_{-j}\cdot\sum_{j=1}^{n}\frac{S_{-\min}}{S_{-j}}}, \quad j=\overline{1,n}. \tag{5}$$

*Stage* 4: The priorities of the alternatives are determined. The greater is the $Q_j$ the higher is the efficiency (priority) of the project alternative.

The analysis of the method presented makes it possible to state that it may be easily applied to evaluating projects and selecting the most efficient of them while being fully aware of the physical meaning of the process. Moreover, it allowed to formulate a reduced criterion $Q_j$ which is directly proportional to the relative effect of the compared criteria values $x_{ij}$ and significances $q_i$ on the end result.

Significance $Q_j$ of project $a_j$ indicates the degree of satisfaction of demands and goals pursued by the interested parties — the greater is the $Q_j$ the higher is the efficiency of the project (see Table 2).

**Table 2.** Results of the multiple criteria analysis of alternatives

| Quantitative project information | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Analysed criteria | * | Weight | Units | Analysed projects | | | | | |
| | | | | $a_1$ | $a_2$ | | $a_j$ | | $a_n$ |
| $X_1$ | $z_1$ | $q_1$ | $m_1$ | $d_{11}$ | $d_{12}$ | | $d_{1j}$ | | $d_{1n}$ |
| $X_2$ | $z_2$ | $q_2$ | $m_2$ | $d_{21}$ | $d_{22}$ | | $d_{2j}$ | | $d_{2n}$ |
| $X_3$ | $z_3$ | $q_3$ | $m_3$ | $d_{31}$ | $d_{32}$ | | $d_{3j}$ | | $d_{3n}$ |
| … | ... | ... | ... | ... | ... | | ... | | ... |
| $X_i$ | $z_i$ | $q_i$ | $m_i$ | $d_{i1}$ | $d_{i2}$ | | $d_{ij}$ | | $d_{in}$ |
| … | ... | ... | ... | ... | ... | | ... | | ... |
| $X_m$ | $z_m$ | $q_m$ | $m_m$ | $d_{m1}$ | $d_{m2}$ | | $d_{mj}$ | | $d_{mn}$ |
| Sum of maximising normalised rated indicators (project advantages) | | | | $S_{+1}$ | $S_{+2}$ | | $S_{+j}$ | | $S_{+n}$ |
| Sum of minimising normalised rated indicators (project disadvantages) | | | | $S_{-1}$ | $S_{-2}$ | | $S_{-j}$ | | $S_{-n}$ |
| Significance of the project alternative | | | | $Q_1$ | $Q_2$ | | $Q_j$ | | $Q_n$ |
| Priority of the project alternative | | | | $P_1$ | $P_2$ | | $P_j$ | | $P_n$ |
| Project's utility degree | | | | $N_1$ | $N_2$ | | $N_j$ | | $N_n$ |

Sign $z_i$ (±) shows, respectively, the better/poorer value of the criterion of requirements for better stakeholders satisfaction.

*Stage* 5: The degree of project utility directly associates with its relevant quantitative and conceptual information. If one project is characterised as the best comfort, aesthetics and price indexes, while another is shown with better maintenance and facilities management characteristics, both will have obtained the same significance values as a result of the multiple criteria evaluation; this means their utility degree is also the same. With an increase (decrease) in the significance of the project analysed, the project's degree of utility also increases (decreases). The degree of project utility is determined by comparing the project analysed with the most efficient project. In this case, all the utility degree values related to the project analysed will range from 0% to 100%. This will facilitate a visual assessment of the project's efficiency.

The formula used for calculating alternative aj utility degree *Nj* is the following:

$$N_j = \left(Q_j : Q_{max}\right) \cdot 100\%. \tag{6}$$

here $Q_j$ and $Q_{max}$ are the significances of the property obtained from the equation 5.

## 4 Conclusions

Research object that is being analyzed by the authors of this present research may be described as a life cycle of the construction and real estate industry, the stakeholders involved and as the micro, meso and macro environments that have some particular impact on a life cycle in making an integral whole. A complex analysis of the formulated research object was performed with the help of Construction and Real Estate Crisis Management Model and Recommended System which were especially developed for this purpose.

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